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Original Article

Polygraphic respiratory events during sleep in children treated with home continuous positive airway pressure: description and clinical consequences

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ABSTRACT

Objective: Data are scarce on respiratory events during sleep for children treated at home with continuous positive airway pressure (CPAP). The present study aimed to characterize the respiratory events with CPAP during sleep and to analyze their clinical consequences.
Patients/Methods: Consecutive polygraphies (PG) performed on stable children treated with CPAP were analyzed and scored using SomnoNIV Group definitions. For every respiratory event, the presence of a 3% oxygen desaturation and/or an autonomic arousal was systematically searched. Nocturnal gas exchange was assessed using summary data of oximetry and transcutaneous carbon dioxide pressure recordings.
Results: Twenty-nine consecutive polygraphies, performed on 26 children (mean age 7.8 ± 6.2 years, mean CPAP use 10.6 ± 14.4 months), were analyzed. The index of total respiratory events was low (median value 1.4/h, range 0–34). The mean number of different types of respiratory events per PG was 2 ± 1 (range 0–4), with always a predominant event. Partial or total upper airway obstruction without a decrease in ventilatory drive was the most frequent event and was the most frequently associated with an oxygen desaturation (in 30% of the events) and an autonomic arousal (in 55% of the events). Weak correlations were observed between nocturnal oximetry and PG results.
Conclusions: The index of respiratory events during CPAP treatment for stable children is low. As these events may be associated with an oxygen desaturation or an autonomic arousal, and as nocturnal gas exchange cannot predict PG results, a systematic sleep study seems justified for the routine follow-up of children treated with CPAP.

1. Introduction

Obstructive sleep apnea syndrome (OSAS) in children is a relatively common disease, with a reported prevalence that varies between 1 and 5% of the pediatric population [1]. Since adenotonsillar hypertrophy constitutes the most common cause of OSAS, adenotonsillectomy represents the first-line and most efficient treatment in children [1]. However, residual OSAS is common in children with underlying disorders such as Down syndrome, craniofacial abnormalities, or obesity. In these cases, continuous positive airway pressure (CPAP) represents an effective treatment [2–7].

In children with OSAS, manual titration of CPAP during attended laboratory polysomnography (PSG) is recommended [8], but such a procedure is time consuming and not feasible in all pediatric centers. Therefore, CPAP is usually set up during the day, according to the clinician's experience and the patient's characteristics. The optimal CPAP level is then adjusted according to nocturnal tolerance to treatment, normalization of nocturnal gas exchange,

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and the disappearance of OSAS symptoms. However, once CPAP is successfully instituted, validated follow-up guidelines are lacking. Current guidelines recommend a periodic reassessment of CPAP pressure [9]; a large adult series has shown the need for an active re-evaluation of pressure therapy, even after accurate titration studies [10,11]. This may be even more relevant for children whose condition may improve with age due to a physiological increase in upper airway caliber and patency, or worsen because of weight gain or upper respiratory infections or allergy. However, very few studies have assessed the need for pressure changes over time in children having CPAP, and little is known about the type and incidence of the different residual respiratory events [2,12,13]. Furthermore, the current definitions of respiratory events during noninvasive ventilation (NIV) and CPAP derive from those in spontaneous breathing and do not accurately take into account the complex interaction between the patient and the response or reaction of a ventilator [14].

Recently, the SomnoNIV Group proposed a systematic scoring analysis of respiratory events observed with polygraphy (PG) during NIV [15]. These criteria were originally set up for NIV, taking into account the events generated by the patient, the ventilator, or the patient–ventilator interaction. However, CPAP differs from NIV, as it delivers a positive pressure during the whole respiratory cycle without actively assisted inspiration [16]; therefore, it is not considered to be a ventilatory mode per se. However, except for patient–ventilator interaction, all of the other SomnoNIV respiratory events may occur during CPAP, such as: unintentional leaks, partial or total upper airway obstruction (UAO) without or with decrease in ventilatory drive (DVD), DVD, and mixed events.

The aim of the present study was to characterize respiratory events in infants and children having CPAP treatment at home, according to the SomnoNIV Group definitions, and to examine the clinical consequences of these events (ie, the occurrence of an oxygen desaturation or an autonomic arousal). Whether oximetry and transcutaneous carbon dioxide tension ($PtcCO_2$) were associated with the occurrence of respiratory events during CPAP therapy was also explored.

2. Materials and methods

2.1. Patients

All PGs performed between October 2011 and February 2014 in consecutive children who were treated with noninvasive CPAP at home were analyzed. All sleep studies were performed in a dedicated NIV and sleep unit in a tertiary pediatric university hospital. Polygraphies were retained for analysis when: (1) patients were clinically stable (ie, with no infection, unscheduled medical visit or hospitalization in the previous month); and (2) patients were using CPAP for at least one month. The study was conducted in agreement with the French regulations and received appropriate legal and ethical approval from the Institutional Review Board of the French Society for Respiratory Medicine (Société de Pneumologie de Langue Française).

2.2. CPAP therapy

All patients received standard care for the treatable causes of their disease. Patients with persistent OSAS after surgical and/or medical treatment, or with non-treatable causes of OSAS, were eligible for CPAP. Criteria to initiate CPAP were chosen individually for every patient and were based on an apnea-hypopnea index (AHI) >10 events/h, and/or a pulse oximetry (SpO_2) <90% for >2% of sleep time and/or a $PtcCO_2$ >50 mmHg for >2% of sleep time.

Children and families were instructed about the CPAP device and the interface. The devices used were: VPAP IV and S9 series (ResMed™, North Ryde, NSW, Australia); Remstar Plus (Philips Respironics™, Murrysville, PA, USA); and ICON (Fisher & Paykel™, Auckland, New Zealand). Interfaces were chosen to obtain the best tolerance and comfort [16]. Therapy was started in the hospital by experienced staff during practical daytime sessions, and then adjusted during consecutive nights in order to achieve an at least 6 h/night use of CPAP, a normalization of nocturnal gas exchange (defined by a SpO_2 >90% and a maximal $PtcCO_2$ <50 mmHg during sleep with CPAP), and the disappearance of sleep disordered breathing-related symptoms. Routine CPAP titration with PG as well as a control PG with CPAP before discharge was not feasible. Patients were discharged after careful education was given to them and their parents. A home-care provider trained in pediatric CPAP/NIV performed a home visit on the day of discharge, after one week and then every 1–3 months.

A systematic overnight PG with CPAP was performed in the hospital 1 month after treatment initiation and then every 2–6 months, according to the child's age and underlying disease. When possible, objective adherence to treatment was downloaded from the built-in software of the device at every hospital and home-care provider visit [17].

2.3. Nocturnal ventilatory polygraphy

Polygraphy was performed using the SOMNOscreen device (SOMNOscreen™ plus PSG+, SOMNOmedics GmbH, Germany) or CID 102* (Cidelec, Angers, France). The recorded data included: airflow, using a pneumotachograph; airway pressure in the CPAP line; body position; body movements; thoracic and abdominal movements, assessed with piezoelectric belts for the SOMNOscreen (SleepSense, Multiple use Inductive Plethysmography Band, S.L.P. Ltd., Israel) or with inductance belts for the CID 102* (Cidelec, Saint Gemme sur Loire, France); SpO_2; and photoplethysmographic pulse-wave amplitude. The pneumotachograph was inserted between the interface and the circuit. Polygraphy analysis was started at sleep onset. Periods with artefacts were removed from analysis. A minimum of 4 h of recording during sleep with CPAP was required for inclusion in the present study.

An autonomic arousal was identified as a reduction in pulse-wave amplitude greater than 30% of the baseline amplitude [18,19]. Mean and minimal nocturnal SpO_2 as well as the percentage of nighttime spent with a SpO_2 <90% were recorded. An oxygen desaturation was defined as a fall in SpO_2 of at least 3% and the oxygen desaturation index was defined as the number of desaturations/h of PG recording. For the present study, nocturnal hypoxemia was defined as the presence of a SpO_2 ≤90% for at least 2% of nighttime PG recording [20], and the oxygen desaturation index was considered as abnormal when >1.4/h of PG recording [21].

2.4. Respiratory events

Respiratory events (see online supplement) were scored according to the consensus opinion definitions of the SomnoNIV Group [15]. In contrast to NIV [22], only five types of events were analyzed during CPAP: unintentional leaks, UAO without or with DVD, DVD, and mixed events (Table 1); the analysis of patient–ventilator asynchrony was not applicable for this spontaneous breathing mode. As no scoring algorithm for respiratory events during CPAP has been validated in children, the index of respiratory events was arbitrarily defined as the number of total respiratory events/h of PG recording. This index was then stratified into four categories of severity: <1.5 events/h (considered as a normal CPAP-PG); 1.5–4.9 events/h; 5–10 events/h; and >10 events/h, by extrapolation from the AHI [1].

Table 1
Definition of the SomnoNIV respiratory events adapted for continuous positive airway pressure.

Respiratory event	Airway pressure	Airflow	Thoracic and abdominal movements
Unintentional leaks	• Stable with moderate leaks (the device is able to compensate) • Decreased with important leaks (the device is not able to compensate)	• Increased • Increased in inspiratory time with a lack of decrease of inspiratory flow	• Maintained • Reduced in cases of severe leaks
Partial or total airway obstruction without decrease in ventilatory drive	Maintained	Reduced	• Maintained or increased • Opposition of phase may occur
Partial or total airway obstruction with decrease in ventilatory drive	Maintained	Reduced	Decreased
Decrease in ventilatory drive	Maintained	Proportional reduction in airflow and thoracic and abdominal movements	
Mixed event: partial or total closure of the upper airways and reduced ventilatory drive followed by passive closure of the airways and resumption of ventilatory drive	Synchronous reduction in flow, thoracic and abdominal movements and respiratory rate with resumption of thoracic and abdominal movements before restoration of normal flow		

2.5. Overnight carbon dioxide

Overnight $PtcCO_2$ recordings were performed simultaneously with the SenTec Digital Monitor (SenTec^{Inc}, Therwil, Switzerland). Mean maximal $PtcCO_2$ and the percentage of nighttime spent with a $PtcCO_2$ >50 mmHg were recorded [23]. For the present study, nocturnal hypercapnia was defined by a $PtcCO_2$ ≥50 mmHg for at least 2% of nighttime PG recording [20].

2.6. CPAP settings changes

The CPAP settings were adapted when the index of total respiratory events was >5 events/h and/or abnormal nocturnal gas exchange, taking into account the child's underlying condition. A follow-up control PG was systematically scheduled to assess the efficacy of the CPAP changes.

2.7. Statistical analysis

All of the data are presented as mean and standard deviation (SD), or median and range. Pearson's product-moment correlation coefficient (parametric test) or Spearman's rank order correlation (nonparametric test) coefficient (r) was calculated to assess the correlation between the markers of nocturnal gas exchange, the duration of CPAP treatment and PG indexes. Sensitivity, specificity, positive and negative predictive values, and likelihood ratios of the markers of nocturnal gas exchange to detect patients with or without an abnormal PG index of total respiratory events were determined. A p-value of <0.05 was considered for significance.

3. Results

A total of 29 PGs, performed in 26 patients, were analyzed (Table 2). Three patients had two PGs, with a mean delay of 16 months (range 3–24 months). Mean age at PG was 7.8 ± 6.2 years, with four patients being younger than one year old at the time of the study. In the 21 patients older than two years of age, three were overweight (BMI percentile between 85th and 95th) and three were obese (BMI percentile above 95th). Mean duration of CPAP use was 10.6 ± 14.4 months.

All of the PGs, except three, were performed under a constant CPAP pressure with a mean pressure of 7.7 ± 1.5 cmH_2O. One PG was performed in a 16-year-old boy with an autotitrating CPAP of 8–12 cmH_2O. Another 15-year-old boy had two PGs, the first with an autotitrating CPAP of 5–10 cmH_2O, and after two years with an autotitrating CPAP of 7–14 cmH_2O. One PG was performed in a 2-year-old boy, in whom CPAP was inadvertently set in the autotitrated mode (4–7 cmH_2O) instead of a 7 cmH_2O constant CPAP.

Mean duration of PG recording was 7:10 ± 1:30 h:min (Table 3). Mean SpO_2 was 97 ± 1% with a mean percentage of nighttime spent with a SpO_2 <90% of 0.2 ± 0.5%. Only one patient spent >2% of nighttime with a SpO_2 <90%. Mean oxygen desaturation index was 3.8 ± 5.2/h, with an oxygen desaturation index >1.4/h in 17 PGs. Mean $PtcCO_2$ was 40 ± 4 mmHg, with a $PtcCO_2$ >50 mmHg for >2% of nighttime being observed in four PGs. Objective CPAP adherence data were

Table 2
Demographic data and characteristics of the patients (n = 26).

Female to male ratio (F/M)	6/20	
Age, years (mean ± SD)	7.8 ± 6.2	
Time of follow-up, months (mean ± SD)	10.6 ± 14.4	
Predisposing conditions	- Down syndrome	3
	- Treacher Collins syndrome	3
	- Polymalformative syndrome	3
	- Idiopathic OSAS	3
	- Achondroplasia	2
	- CATCH-22 syndrome	2
	- Neurofibromatosis type 1 with subglottic neurofibroma	1
	- Bronchopulmonary dysplasia	1
	- Turner syndrome	1
	- Menkes syndrome	1
	- Cherubism	1
	- Beckwith–Wiedemann syndrome	1
	- Pycnodysostosis	1
	- Niemann–Pick disease type A	1
	- Post-intubation laryngeal paralysis	1
	- Prader–Willi syndrome	1

Abbreviations: OSAS, obstructive sleep apnea syndrome.

Table 3
Polygraphy duration, CPAP level, nocturnal gas exchange, and objective adherence to treatment (mean ± SD) (n = 29).

Polygraphy duration (h:min)	7:10 ± 1:30
Mean CPAP level (cmH_2O)	7.7 ± 1.5
Nocturnal gas exchange	
Mean SpO_2 (%)	97 ± 1
Minimal SpO_2 (%)	89 ± 6
Time spent with SpO_2 <90% (%)	0.2 ± 0.5
Oxygen Desaturation Index (number/h)	3.8 ± 5.2
Mean $PtcCO_2$ (mmHg)	40 ± 4
Maximal $PtcCO_2$ (mmHg)	46 ± 7
Time spent with $PtcCO_2$ >50 mmHg (%)	1.7 ± 6.0
Objective CPAP adherence over the last month (n = 20)	
Average use per night (h:min)	7:40 ± 2:10
Average use per month (nights/month)	28 ± 2

Abbreviations: CPAP, continuous positive airway pressure; $PtcCO_2$, transcutaneous carbon dioxide tension; SpO_2, pulse oxymetry.

Table 4
Occurrence of SomnoNIV respiratory events during CPAP ($n = 29$).

	Unintentional leaks	Partial or total UAO without decrease in ventilatory drive	Partial or total UAO with decrease in ventilatory drive	Decrease in ventilatory drive	Mixed events
Number of polygraphies with the event, *n* (percentage)	12 (41%)	19 (65%)	13 (45%)	12 (41%)	3 (10%)
Event index/h, median (range)	0.0 (0.0–3.1)	0.4 (0.0–7.9)	0.0 (0.0–4.8)	0.0 (0.0–25.2)	0.0 (0.0–2.0)
Percentage of time spent with each event, median (range)	0.0 (0.0–42.4)	0.7 (0.0–13.7)	0.0 (0.0–7.4)	0.0 (0.0–5.3)	0.0 (0.0–4.0)

Abbreviations: UAO, upper airway obstruction.

available for 20 patients (69%). In the previous month, the mean use per night was 7.4 ± 2.1 h and the mean number of night use was 28 ± 2 days.

The median index of total respiratory events was low, at 1.4 events/h (range 0–34), with 15 patients having an index <1.5 events/h, nine patients with an index between 1.5–4.9 events/h, two patients with an index between 5–10 events/h, and three patients with an index >10 events/h. The median index of each respiratory event was also low, as was the median percentage of time spent with each respiratory event (Table 4). Concerning the number of different respiratory events per PG, only one PG showed no respiratory event (Fig. 1). One to four different respiratory events were observed on the 28 remaining PGs. The mean number of single events per PG was 2 ± 1. However, the time spent with these different respiratory events was not equally distributed, with one event being always largely predominant. For the 29 PGs, the median time spent with a predominant event represented 92% (range 42–100%) of the total time spent with all types of respiratory events. Fig. 2 shows the association between the five types of respiratory events and an oxygen desaturation and/or an autonomic arousal. Partial or total UAO without DVD was frequently associated with an oxygen desaturation (30%) or an autonomic arousal (55%). Conversely, unintentional leaks and mixed events were rarely associated with an oxygen desaturation or an autonomic arousal. Weak correlations were observed between the index of total respiratory events and minimal SpO_2 ($r = -0.400$, $p = 0.031$), mean SpO_2 ($r = -0.411$, $p = 0.027$) and the oxygen desaturation index ($r = +0.377$, $p = 0.044$). No correlation was observed between the PG results and the duration of CPAP treatment.

Table 5 shows the concordance between the different thresholds of respiratory events index and the markers of nocturnal gas exchanges. When defining abnormal gas exchange as a SpO_2 ≤90% for at least 2% of nighttime, and/or a $PtcCO_2$ ≥50 mmHg for at least 2% of nighttime, and/or an oxygen desaturation index ≥1.4/h, abnormal gas exchange had low sensitivity (64%), specificity (47%), positive predictive value (53%), negative predictive value (58%), and very low discriminative properties (positive likelihood ratio = 1.20; negative likelihood ratio = 0.77) to detect an index of total respiratory events ≥1.5/h. When defining abnormal gas exchange by excluding the oxygen desaturation index, abnormal gas exchange

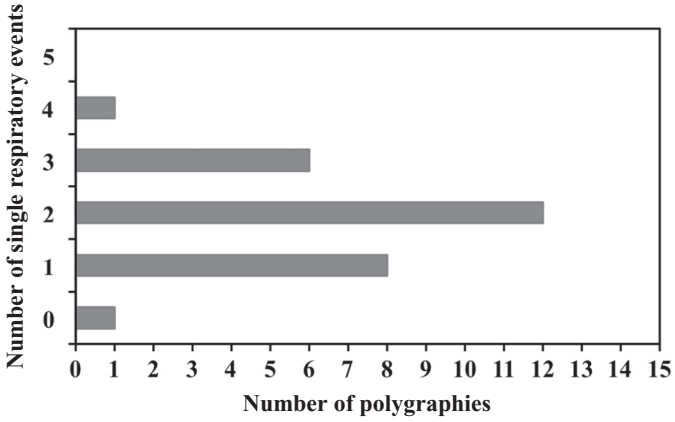

Fig. 1. Number of single respiratory events per polygraphy. No SomnoNIV respiratory events were observed in only one polygraphy while in the majority of polygraphy ($n = 12$), two types of respiratory events were identified.

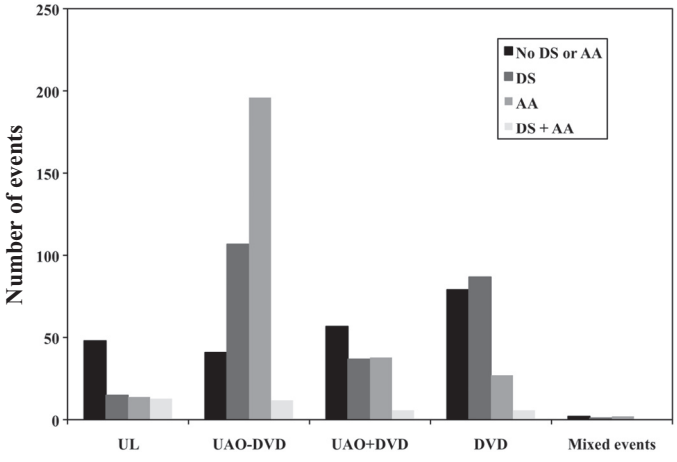

Fig. 2. Number of the different respiratory events associated with oxygen desaturation and/or autonomic arousal. *Abbreviations*: AA, autonomic arousal; DS, oxygen desaturation; DVD, decrease in ventilatory drive; UAO-DVD, upper airway obstruction without decrease in ventilatory drive; UAO+DVD upper airway obstruction with decrease in ventilatory drive; UL, unintentional leaks

Table 5
Concordance between polygraphy results and markers of nocturnal gas exchange.

Abnormal gas exchange (SpO_2 ≤90% for at least 2% of nighttime and/or $PtcCO_2$ ≥50 mmHg for at least 2% of nighttime) + abnormal oxygen desaturation index (ODI ≥1.4/h).		
Total events index	Normal gas exchange ($n = 12$)	Abnormal gas exchange ($n = 17$)
Index <1.5/h	7	8
Index [1.5–4.9]/h	5	4
Index [5–10]/h	0	2
Index >10/h	0	3
Abnormal gas exchange (SpO_2 ≤90% for at least 2% of nighttime and/or $PtcCO_2$ ≥50 mmHg for at least 2% of nighttime):		
Total events index	Normal gas exchange ($n = 25$)	Abnormal gas exchange ($n = 4$)
Index <1.5/h	14	1
Index [1.5–4.9]/h	8	1
Index [5–10]/h	2	0
Index >10/h	1	2

Abbreviations: ODI ≥3%, oxygen desaturation index (events/h); $PtcCO_2$, transcutaneous carbon dioxide tension; SpO_2, pulse oxymetry.

had a very low sensitivity (21%), a very good specificity (93%), a good positive predictive value (75%), a low negative predictive value (56%), but low to very low discriminative properties (positive likelihood ratio = 3.00; negative likelihood ratio = 0.85) to detect an index of total respiratory events ≥1.5/h.

CPAP settings or interfaces were changed in seven cases. In three cases, the CPAP level was increased due to persistent UAO. One adolescent was switched from a constant CPAP to an autotitrated CPAP due to positional-related UAO. The CPAP level was decreased in one patient, and one patient had persistent alveolar hypoventilation, despite maximal CPAP, and was successfully switched to NIV. In one case, the interface was changed because of excessive unintentional leaks.

4. Discussion

The present study was the first to characterize and score persistent respiratory events during sleep with CPAP by means of PG, according to the SomnoNIV Group definitions, in a group of stable children treated with CPAP at home. It was also the first to report the clinical consequences in terms of oxygen desaturation or autonomic arousal. It was found that, even if almost every PG showed the persistence of respiratory events, the indexes of respiratory events were generally low. However, some events, such as UAO without DVD and DVD, were frequently associated with an oxygen desaturation or an autonomic arousal. More importantly, nocturnal gas exchange was not able to predict PG results, underlining the usefulness of systematic nocturnal gas exchange associated with PG during home CPAP treatment in children.

The present study showed that the number of respiratory events was low. In a similar study analyzing respiratory events during NIV in children, unintentional leaks and patient–ventilator asynchrony were the most common events [22]. As expected, considering that CPAP was initiated mainly because of persistent OSAS, the most common respiratory event was partial or total UAO without DVD. Even if the frequency of this event was relatively low, it was important to be detected because it was commonly associated with an oxygen desaturation and/or an autonomic arousal. On the contrary, even if unintentional leaks were observed during nearly half of the PGs, this event was rarely associated with an oxygen desaturation and/or an autonomic arousal. However, the present study does not give the clinical significance of these objective consequences for an individual patient. This is a major issue, which requires another study that includes outcomes such as comfort and compliance with CPAP, subjective sleep quality, as well as behavior and neurocognitive improvement.

In the present study, CPAP and/or interface changes were performed in 25% of the patients. Changes were made, taking into account the incidence of respiratory events, but also their clinical consequences (ie, an oxygen desaturation and/or an autonomic arousal, the nocturnal gas exchange data and the patient's characteristics). Current guidelines recommend a periodic reassessment of CPAP pressure [9]. In a large group of adult patients, pressure changes were necessary in almost 60% of cases after three months from the initiation of CPAP [11]. An increase in CPAP level was determined by the presence of an index of obstructive events >5/h [11]; therefore, complete abolition of events was not the expected goal. However, the timing of CPAP assessment and the criteria for CPAP changes have not been validated in children. In a recent study, a change in CPAP settings was recommended in 27 of the 41 (65%) children under long-term CPAP care and who performed a PSG titration study [13]. Another retrospective analysis of PG and PSG studies in children having CPAP reported that a pressure change was necessary in 22/33 (66%) cases in order to obtain total disappearance of any apnea, hypopnea or hypoventilation [12]. Few data exist about an acceptable level of persistent respiratory events after OSAS treatment in children, with some authors accepting a residual AHI <5/h after adenotonsillectomy [24]. These data show that there is no agreement on the objective or acceptable levels of events and their clinical consequences during home CPAP for children. Within this context, and without formal recommendations, it was arbitrarily decided to score an index of total respiratory events ≥1.5/h as abnormal, as this cut-off is considered to be abnormal for the AHI in children [1]. Future studies should aim at analyzing respiratory events and their consequences by means of a validated scoring system, in order to establish clinically relevant and acceptable threshold events.

Abnormal nocturnal gas exchange, defined by a SpO_2 ≤90% for at least 2% of nighttime and/or a $PtcCO_2$ ≥50 mmHg for at least 2% of nighttime, was observed only during four of the 29 PGs. This may be explained in part by the absence of OSAS-related symptoms and the good tolerance to CPAP treatment in the present population. It has to be taken into account that the studies were performed in a hospital, which may have led to an overestimation of abnormal gas exchange recordings, as gas exchange may be better in children treated with NIV or CPAP during home recording [25]. Another important observation of the present study was the poor predictive values of markers of gas exchange to detect a pathological respiratory event index. This implies that the presence of normal markers of gas exchange do not withstand the performance of an overnight PG.

The present study presented several limitations. A full PSG was not performed because it is more difficult and time-consuming than a PG; therefore, there was no information on sleep architecture, sleep time and quality, and EEG arousals. Consequently, the pulse-wave amplitude was used as a marker of an autonomic arousal [26]; this marker has shown its usefulness in assessing the efficacy of NIV during sleep in children and has also been used to assess the clinical consequences of persistent respiratory events during NIV in children [27]. It would have been interesting to determine the occurrence of hypercapnia after the different respiratory events; however, because of the time lag of the CO_2 response, this was not feasible [23,28]. Moreover, none of the patients underwent an attended titration study during the initiation of CPAP, which could have led to a lower rate of CPAP changes during follow-up. However, rate of CPAP changes was relatively low in the present study, probably because patients were initiated to CPAP by well-trained and experienced staff. Of note, PGs were performed in children with a different period of CPAP use. Finally, this was a very selective population, representing tertiary care pediatrics with unique conditions, which is not generalizable to otherwise healthy children with OSAS. However, recent epidemiological data show that this population is growing in the pediatric population [29,30].

The premise of the use of a PG is basically to assure the clinician that the titration is appropriate. The algorithms of the current devices deliver a large number of parameters such as the airway pressure, leaks, respiratory rate, vital volume, and minute ventilation, as well as an apnea index and an apnea-hypopnea index. Ideally, if these data were accurate, they would not require a PG. However, these data need to be validated against standard PG measurements, as data given by NIV devices are not always accurate, even in adults [31]. Moreover, all CPAP devices have been designed for adults or children above a minimal weight and not for younger children.

In conclusion, the present study showed that persistent respiratory events are relatively uncommon in asymptomatic children treated with CPAP at home, in contrast to children treated with home NIV [22]. However, as these events may be associated with an oxygen desaturation and/or an autonomic arousal, and as markers of nocturnal gas exchange poorly predict PG results, a systematic sleep study seems justified for the routine follow-up of children treated with CPAP at home. Further studies are needed to validate the scoring

of respiratory events during CPAP in children, to assess the usefulness and clinical relevance of PSG vs PG, as well as the optimal timing for sleep studies in children.

Conflict of interest

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: http://dx.doi.org/10.1016/j.sleep.2014.07.030.

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Appendix: Supplementary material

Supplementary data to this article can be found online at doi:10.1016/j.sleep.2014.07.030.

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